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SUBSTITUTE SPECIFICATION
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DEVICE, SYSTEM AND METHOD FOR MEASURING REICHENBACH CLOCK SYNCHRONIZATIONS

FIELD OF THE INVENTION

The present invention is directed to a device, system and method for measuring the Reichenbach clock synchronization coefficients and the resulting vector velocity of light.

BACKGROUND OF THE INVENTION

This invention relates in general to the determination of velocity as defined by the cosmic background Doppler shift by measuring the Reichenbach clock synchronization coefficients and the resulting vector velocity of light in the oscillations of photon tunneling times.

Einstein first introduced the idea of an ultimate particle speed known as *c*, the speed of light, with the publication of his special theory of relativity in 1905. Since this publication, scientists have shown that *c* is not an upper-limit on a particle's speed, but a barrier to acceleration. These mathematical studies have shown that while it is not possible to accelerate an object to a velocity faster than light, it is possible for an object to have a velocity greater than *c*.

In mathematical terms the one-way vacuum velocity of light from A to B is c(AB), which is described by the equation:

$$c(AB) = c/2\varepsilon(AB) \qquad (1)$$

where ε(AB) are the Reichenbach clock synchronization coefficients. The vector velocity c(AB) is only isotropic in a preferred reference frame and the round trip vacuum speed of light, c, is constant because:

$$\varepsilon(AB) = 1 - \varepsilon(BA) \qquad (2)$$

In the Lorentz covariant theoretical work, without "superluminal" energy flow, any inertial frame can be chosen as the preferred frame. Only by using "superluminal" energy flow, then, can a single preferred reference frame be used to measure the vector vacuum velocity of light.

The first evidence of energy moving at velocities greater than c was observed by radio engineers at the turn of the century. They learned that radio signals in the upper atmosphere traveled faster than light. The reason was that the radio waves were moving through ionized gas and not normal air. In effect, these radio waves' pulses have two different velocities, a group velocity, or the velocity of the pulse packet, and a phase velocity, the velocity of the individual waves within the group. In this example, the phase velocity of the radio waves, or the internal velocity of the individual waves within the radio wave pulse packet were moving faster than light. A more complete discussion of these early "superluminal" radio wave experiments can be found in the text *Faster Than Light*, by Nick Herbert, pg. 56-58, (1988).

Systems designed to transmit energy at "superluminal" velocities are also well-known in the art of quantum mechanics. One type of conventional "superluminal" energy transport method employs the phenomenon known as quantum barrier penetration, or tunneling. Under quantum theory, a quantum particle can be thought of as a wave packet, its width in space related to its velocity through the Heisenberg Uncertainty Relation. A common interpretation of this wave packet is that it represents a probability distribution. This means that where the amplitude of the wave packet is the greatest corresponds to the position in space with the highest probability of finding, or measuring, the particle. When the quantum wave packet is incident upon a barrier, it is partially reflected off the barrier and partially transmitted through the barrier. Since the packet transmitted through the barrier is a portion of the original probability distribution there is a small but finite probability of measuring the location of the quantum particle on the far side of the barrier. This phenomenon is known as tunneling and

is well-known and accepted. However, a question arises as to the time required for the particle to achieve barrier penetration.

Several groups studying the phenomena of tunneling have shown that the tunneling velocities, or interaction times, for a variety of particles to pass through a barrier exceed c. For example, "superluminal" velocities have been measured for light pulses traveling through an absorbing material. "Superluminal" velocities have also been measured for the propagation for microwaves through a “forbidden zone” inside square metal waveguides. For a more detailed discussion of these experiments see, NEW SCIENTIST, vol. 146, pg. 27 (1995).

More recently, a group at the University of California at Berkeley measured "superluminal" tunneling times for visible light tunneling through a dielectric mirror using a Hong-Ou-Mandel interferometer. Similar experiments by a group in the University of Vienna in 1994 confirmed the Berkeley study and also showed that "superluminal" tunneling times could be obtained for increasingly large barrier thicknesses. For a more detailed discussion of these experiments see, NEW SCIENTIST, vol. 146, pg. 29 (1995).

Finally, in 1995, a group headed by Prof. Nimtz sent a microwave signal broadcasting Mozart's 40^{th} Symphony across 12 cm of space at 4.7 times the speed of light. For a more detailed discussion of this experiment see, NEW SCIENTIST, vol. 146, pg. 30 (1995).

In effect, these experiments show that tunnel times are independent of tunnel length, demonstrating the Hartman effect and tunneling. Under this regime the tunneling time, Δt, is a saturated value and the Heisenberg uncertainty principle is written as follows:

$$\Delta\tau\Delta E = \hbar(1+O)/2 \qquad (3)$$

where, ħ, is the Heisenberg constant and, O, represent the higher order corrections to the tunneling time. This principle is referred to as the "energy borrowing" uncertainty principle, where the energy ΔE, must be "paid back" in a time less that Δt, regardless of the energy flow speed or group velocity required to do so. A more detailed explanation of the physics of tunneling is provided in the following references, each incorporated herein by reference: R.Y. Chiao, "Tunneling Times and Superluminality: a Tutorial", *quant-ph/9811019, 7 Nov. 1998, at LANL*; J. Jakiel et al., "On Superluminal Motions in Photon and Particle Tunnelings", *quant-ph/9810053, 16 Oct. 1998, at LANL*; A. Kempf, "A generalized Shannon Sampling Theorem, Fields at the Plank Scale as Bandlimited Signals", *hep-th/9905114, 2 Mar. 2000, at LANL*; P. Bamberg and S. Sternberg, "A course in Mathematics for Students of Physics 2", *Cambridge University Press 1990, Sect. 21.4*; J. Rembielinski, "Superluminal Phenomena and the Quantum Preferred Frame", *quant-ph/0010026, 6 Oct. 2000, at LANL*; J. Rancourt, "Optical Thin Films User Handbook", *SPIE Optical Engineering Press, 1996, Apendix C*; Hawking & Ellis, "The Large Scale Structure of Space-Time", *Cambridge University Press, 1973, Sect. 4.3*.

While these experiments and texts clearly show the possibility of transmitting various forms of electromagnetic radiation faster than the speed of light, thus far no system has been developed to determine the one-way velocity vector of light utilizing these "superluminal" energy transmissions.

SUMMARY OF THE INVENTION

The present invention is directed to a device, system and method for measuring the one-way velocity of light using selective transmission technology to provide a "superluminal" energy flow.

This invention utilizes selective transmission technology to provide a "superluminal" energy flow. Selective transmission technology actively selects the wavefront components within a wavepacket for transmission through a Quantum barrier. The selective transmission technology or device accomplishes this by

choosing a Quantum barrier, or air gap length, that selectively transmits only the wavefront of a wavepacket. The selective transmission device can then transmit these wavefront components more efficiently, giving these components a head start. These wavefront components contain Quantum information that is then used to completely reconstruct the wavepacket on the far side of the barrier before the energy of a free photon would have arrived on the far side. The transmitted wavefront information is used to completely reconstruct the wavepacket with energy borrowed from the vacuum on the far side of the barrier. The energy in the photon before the barrier must traverse the barrier at a speed that is FASTER than the vacuum speed of light. This is required to "pay-back" the energy borrowed from the vacuum on the far side of the barrier in a time that is equal to the time allowed by Quantum mechanics, or by the saturated Heisenberg energy borrowing uncertainty principle. This Quantum requirement along with the selective-transmission technology generates "superluminal" group velocities and "superluminal" energy flow. In summary, the chosen air gap length amplifies the front part of the wavepacket using energy borrowed from the vacuum and Quantum information provided by selectively transmitted wavefront wavepacket components to completely reconstruct the wavepacket on the far side of the Quantum barrier. This causes "superluminal" energy flow that is required to pay back the energy debt within the time required by Quantum mechanics. However, because of the time it takes to prepare the energy for "superluminal" transmission using selective-transmission technology the "superluminal" energy flow contains no "superluminal" classical-information.

When the tunneling direction is in the direction of the red shift in the cosmic microwave background the tunneling time is shortest, and when the tunneling is in the blue shift direction the tunneling time is longest. Because the measured daily oscillation of the tunnel time is equivalent to the change in the vector vacuum velocity of light with tunneling direction and the tunneling direction is itself equivalent to the cosmic microwave background dipole direction created by the

Doppler shift caused by the Earth's motion, the one-way light velocity can be measured.

In light of the above, in one embodiment, the invention is directed to a "superluminal" transmitter device comprising a transmission source, a receiver, and a selective-transmission device for receiving the transmission from the transmission source and selectively transmitting only the wavefront portion of the transmission through a barrier.

In a particular embodiment, the selective-transmission device comprises an air-gap barrier having proximal and distal ends formed from effective transmission barriers and an air gap disposed between the proximal and distal barriers such that a transmission from the transmission source enters the proximal end of the barrier tunnels across the air gap and exits the distal end of the barrier. In this embodiment, the length of the air-gap is dependent on the wavelength of the wave-packet transmission such that the length of the air-gap is adjusted to efficiently transfer the wavefront of the transmission wave-packet.

In another particular embodiment, the transmission source comprises a radio source in signal communication with a transmission antenna and the receiver comprises an amplifier in signal communication with a receiver antenna.

In yet another particular embodiment, the invention is directed to a compass, comprising using the selective transmission device to measure the vector velocity of light.

In still another particular embodiment, the invention is directed to a clock and calender, comprising using the selective transmission device to measure the vector velocity of light relative to the Earth's motion.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the present invention will be better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic view of an embodiment of the "superluminal" energy transmission device according to the invention.

FIG. 2 is a graphical representation of the of the "superluminal" transmission properties of the present invention.

FIG. 3 is a graphical representation of the "superluminal" transmission properties of the present invention.

FIG. 4 is a graphical representation of the "superluminal" transmission properties of the present invention.

FIG. 5 is a graphical representation of the "superluminal" transmission properties of the present invention.

FIG. 6 is a graphical representation of the "superluminal" transmission properties of the present invention.

FIG. 7 is a graphical representation of the "superluminal" transmission properties of the present invention.

FIG. 8 is a graphical representation of the "superluminal" transmission properties of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to a "superluminal" transmission device for measuring the vector velocity of light. In one embodiment, as shown in FIG. 1, the "superluminal" transmission device **10** comprises a transmission source **12**, a selective-transmission device **14** adapted to receive a transmission from the transmission source **12**, a receiver **16** in signal communication with the selective-transmission device **14** and a monitor **18** adapted to communicate the transmission to a user.

A transmission wavepacket **20** having a wavefront component is introduced into the selective-transmission device **14** from the transmission source **12** such that the transmission wavepacket **20** is conducted through the space between the transmission source **12** and the receiver **16** to the monitor **18** at velocities faster

than the speed of light. The selective-transmission device **14** is placed in proximate relation to the transmission source **12** such that the transmission wavepacket **20** passes through the selective-transmission device **14** and the wavefront component of the transmission wavepacket **20** is transmitted into the receiver **16** creating a signal. A receiver or series of receivers **16**, are adapted to receive the signal and transmit the signal to a monitor **18** in signal communication therewith. Any device having the ability to detect changes in amplitude, frequency, phase or wavelength of the transmission **20** can be used as a receiver **16** and monitor **18**, such as, for example, a radio amplifier in signal communication with an oscilloscope or a Time to Digital Converter (TDC). Additionally, any suitable transmission source **12** may be used in the subject invention, such as, for example, a microwave generator or a radio transmitter so long as detectable levels of electromagnetic radiation are transmitted to the receiver **16** in the form of a transmission wavepacket **20**.

In general terms, the selective-transmission device **14** comprises a quantum air-gap barrier **22**, which is in signal communication with the transmission source **12**. The quantum air-gap barrier **22** comprises a proximal **24** and distal **26** barrier wall and an air-gap **28** having a tunneling, or air-gap, length **30** disposed therebetween. The proximal barrier wall **24** is in signal communication with the transmission source **12** and the distal barrier wall **26** of the air-gap barrier **22** is in signal communication with the receiver **16**. The transmission **20** from the transmission source **12** interacts with the air-gap barrier **22** which selectively transmits the wavefront component of the transmission wavepacket **20** across the air-gap **28** to the receiver **16** at subluminal velocities. The air-gap barrier **22** generates "superluminal" transmission velocities in the wavepacket group component of the transmission **20** by selecting the wavefront component of the transmission wavepacket **20** and more efficiently transmitting that wavefront component across the air-gap **28**. The wavefront component of the transmission wavepacket **20**, is selected by arranging the proximal **24** and distal **26** barrier

walls such that the air-gap length **30** therebetween corresponds to quarter wavelength or multiples thereof of the wavefront component of the transmission wavepacket **20**. By selecting the air-gap length **30** to correspond to the wavelength of the wavefront component of the total transmission wavepacket **20**, the air-gap barrier **22** provides the wavefront component of the transmission wavepacket **20** a head start, in effect causing tunneling of the wavefront component, or tunneling transmission across the air-gap **28** in a tunneling time that is independent of the tunnel distance, or air-gap length, **30**, thus causing the tunneling transmission to cross the air-gap **28** at a "superluminal" group velocity. Any air-gap barrier **22** construct suitable for selecting the wavefront component of the transmission wavepacket **20** from a transmission source **12** and transmitting the wavefront component of the wavepacket **20** across an air-gap **28** at subluminal velocities with a headstart causing "superluminal" group velocities may be used such as, for example, square metal waveguides for microwave transmissions or tanks having a high index of refraction substance such as water for radio transmissions.

In one preferred embodiment, a radio transmission source **12**, a radio receiver **16** and an air-gap barrier **22** comprising a proximal tank **24** and a distal tank **26** aligned parallel to each other across an air-gap **28** are utilized to generate the "superluminal" transmissions. The proximal tank **24** is placed in signal communication with the transmission source **12** and the distal tank **26** is placed in signal communication with the receiver **16**. The tanks **24** and **26** are arranged such that an air-gap **28** is created between having an air-gap length **30** In this embodiment, the tanks **24** and **26** may have any index of refraction suitable to act as a quantum barrier such as, for example, a Plexiglas™ tank filled with water.

To transmit the transmission wavepacket **20** to and from the selective-transmission device **14**, the transmission source **12** and receiver **16** must be positioned relative to selective-transmission device **14** such that the transmission wavepacket **20** passes through the selective-transmission device **14**. In the embodiment shown in the attached figures, a radio transmission source **12** and a

radio receiver **16** utilize antennas **32** directed at the selective-transmission device **14**. However, any suitable design can be used such that the transmission **20** from the transmission source **12** passes through the selective-transmission device **14** and enters the receiver **16**.

A prototype of the "superluminal" transmission device **10** described above was constructed. A NIM-logic pulser **34** (Phillips Scientific model 417 Nuclear Instrumentation Standard Pocket Pulser) in signal communication with an amplifier **36** (RadioShack catalog # 15-1113C) is used as the transmission source **12** and is placed in signal communication with a five-element folded-dipole Yagi antenna **32a** designed for two-meter wavelength radio waves. A second amplifier **38** (RadioShack catalog # 15-1170) in signal communication with a second five-element folded-dipole Yagi antenna **32b** is used as the receiver **16**. Both antennas **32a** and **32b** comprise ¼ inch aluminum ground wire reflector and deflectors, and a #10 copper wire folded dipole. 75 ohm to 300 ohm transformers, (RadioShack catalog # 15-1140), are connected to 75 ohm cables at the antennas **32a** and **32b**. Each antenna **32a** and **32b** is also surrounded by an aluminum screen (not shown), with a 114 cm wide opening along the folded-dipole direction to selectively transmit and receive a signal wavelength at ≤228 cm. The signal from the receiver amplifier **16** is fed into an oscilloscope monitor **18** (Tektronix TDS220). Alternatively a TDC could be utilized as a monitor **18**, such as, for example, an ORTEC 9308 Picosecond Time Analyzer preceded by a 9307 pico-Timing Discriminator. The transmission source **12** signal is also monitored by the oscilloscope monitor **18** via a signal splitter **40** which is placed in signal communication with the radio-wave pulser **34**. The cables leading from the transmission source **12** and the receiver **16** to the oscilloscope monitor **18** are terminated into 75 ohms.

The selective-transmission device **14** comprises an air-gap barrier **22** having proximal **24** and distal **26** barrier walls arranged such that an air-gap **28** lies therebetween. The proximal **24** and distal **26** barrier walls consist of two 4 ft wide

and 2 ft high distilled water tanks. The distilled water layer thickness in each tank is 12.7 mm or ½ inch and the index of refraction is n = 9 and k = 0.002. The water tanks are constructed with ¼ inch thick Plexiglass having an index of refraction of n = 1.6 and k = 0.0. The proximal **24** and distal **26** barrier walls can be adjusted such that the air-gap length **30** between them extends up to 270 cm.

FIGs. 2 to 7 show the results of a typical "superluminal" transmission absent a signal pulse for the "superluminal" transmission device prototype **10** shown in FIG. 1. During a transmission, the source amplifier **36** gain is set at the minimum level and the FM trap is turned on. The cable lengths are adjusted such that the pulser **34** trigger pulse arrives at the oscilloscope monitor **18** just prior to the transmission wavepacket wavefronts **20**. Each transmission measurement contains 128 samples, averaged by the oscilloscope monitor **18**. The source data, or standard is taken with only the proximal barrier wall **24** in place. All error bars are the standard deviation of five data set measurements. FIG. 2 shows data from a source wavepacket measurement. The measured peak to peak time, τ_m, for the source wavepacket is 7.6 ± 0.1 ns, giving a photon wavelength of 228 cm. The large pulse shown below 0 peaking time, τ p, is the pulser trigger which is the rising edge set at -0.4 volts. The peaking time of the source wavepacket, τ p, relative to the pulser trigger is 39.0 ± 0.3 ns. Table 1, below, shows the peak to peak separation times of the various components of the transmission wavepacket **20**. As shown for peak numbers 1 to 3, the higher energy, or lower wavelength, components are in the front part, or nearer the wavefront, of the transmission wavepacket **20**. It is these wavefront components of the transmission wavepacket **20** that are selectively transmitted by the "superluminal" transmission device **10** described above.

Table 1: Peak to Peak Separation Times		
Peak Numbers	Peak to Peak Time (ns)	Wavelength (cm)
1 to 2	6.8	204
2 to 3	6.8	204
3 to 4	7.2	216
4 to 5	7.6 ± 0.1	228
5 to 6	7.6	228

In FIG. 3, the transmitted energy, E_T (mV^2), averaged over time, $<E_T>$, from 0 to 80 ns, is shown verses the air-gap length, L (cm). The maximum transmitted energy, E_T, over 0 to 80 ns occurs at an air-gap length of 57 cm. This energy peak is identified as a 228 cm photon quarter wavelength, indicating that the shorter air-gap lengths transmit the quarter wavelength or higher energy components of the transmission wavepacket **20** more efficiently. This is the mechanism that preferentially selects the front part, components, of the wavepacket **20** for transmission and generates the "superluminal" group velocities shown for a 30 cm air-gap length **30**. The tunneling time, $\Delta\tau$ (ns), is also shown verse the air-gap length, L (cm), in FIG. 3. The flat tops of the shaded boxes identify the regions where the tunneling time is independent of the tunnel, or air-gap, length **30**. As previously described, the tunneling time is defined by the "energy borrowing" Heisenberg uncertainty principle of Equation (3), where the energy must be "paid back" in a time less than the tunneling time regardless of the energy flow speed or group velocity required. The wavepacket **20** that tunnels through the air-gap **28**, peaks prior to the source, or non-tunneling, wavepacket. The measured peaking time difference is defined by the equation:

$$\tau_g = \tau_p - \tau_{psource} \qquad (4)$$

where, τ_g, is the measured group delay time. The tunnel time is then defined by the equation:

$$\Delta\tau = (L/c) + \tau g \quad (5)$$

where, (L/c), is the source time. Peaking times, group delay times and tunnel times as measured during a transmission measurement are listed in Table 2, below.

Table 2: Wavepacket Peak Times, Group Delay Times and Tunnel Times			
Air-Gap Length (cm)	τ_p (ns)	τ_g (ns)	τ (ns)
source	38.96 ± 0.33	—	—
200	38.05 ± 0.26	-0.91 ± 0.42	5.75 ± 0.42
210	37.69 ± 0.33	-1.27 ± 0.47	5.73 ± 0.47
220	37.35 ± 0.26	-1.60 ± 0.52	5.73 ± 0.52
230	37.07 ± 0.48	-1.89 ± 0.58	5.77 ± 0.58
240	36.77 ± 0.60	-2.19 ± 0.68	5.80 ± 0.68

As shown, the tunnel time is independent of the length of the air-gap **28**, indicating an increase in the negative group-delay time for the tunneling portion of the transmission wavepacket **20** as the air-gap length **30** is increased. As shown by FIG. 3, for air-gap lengths between 200 and 240 cm the tunnel time is less than the source time or vacuum speed of light, *c*. The increase in the tunnel time standard deviations with increasing tunnel length measure a lower bound in the tunnel time distributions that are proportional to the tunnel length.

FIG. 4, shows a graph plotting the transmission fraction and tunneling time for a 204 cm wavelength photon verses the air-gap length. The boxes in the figure again show the regions where the tunnel time is independent of the tunnel length. This plot also shows that those regions where the tunnel time is independent of the tunnel length coincide with the selective transmission of the wavepacket front. Thus, selective transmission of the wavefront component of the transmission wavepacket **20** causes "superluminal" group velocities in those transmitted

components.

FIG. 5 graphically shows the effect of this selective transmission. Data for this graph was taken from one 128 sample source data set for an air-gap length of 220 cm. In this measurement a 204 cm wavelength wavefront **20** with a transmission fraction of 0.997 is utilized and the wavepacket front is being actively selected. The straight bold line shows the vacuum speed of light, while the bent bold line depicts the subluminal speed of the selective transmission of the wavefront component of the wavepacket **20**. As shown, the selective transmission creates subluminal velocities in the wavefront components that are much less than *c* but not enough less to hold the energy luminal because they have a headstart. In mathematical terms, the stationary phase tunnel time, τ_s, given by:

$$\tau_s = {}^{\partial\phi}\!/_{\partial\omega} \qquad (6)$$

added to the head-start time, τ_h, caused by selecting the wavefront wavepacket components equals the group velocity tunnel time, $\Delta\tau$. The stationary phase tunnel time, give by Equation 6, is $\tau_s = 46.18$ ns, its peak (or group) value. The head-start time is defined by the equation:

$$\tau_h = \Delta\tau - \tau_s \qquad (7)$$

where, $\tau = 5.73$ ns, and $\tau_h = -40.45$ ns. Under these conditions the head-start time is also defined by the equation:

$$\tau_h = \tau_g - \tau_{psource} \qquad (8)$$

where, $\tau_h = -40.56$ ns. Indicating that by selecting these wavefront components **42** a 40.56 ns head-start can be generated in the transmission, advancing the energy

1.6 ns for "superluminal" energy flow.

FIGs. 6 and 7 show tunnel and source data for single data sets, each containing 128 samples averaged by the scope. The tunnel data for FIG. 6 is from a measurement taken utilizing an air-gap length of 220 cm. The negative group delay time of -2.1 ns is for this data set. The group delay time average over all five data seta taken at 220 cm is -1.6 ns. In this plot, the tunneled wavepacket contains less energy than the source wavepacket. However, from the transmission fraction analysis it is shown that the front part of the wavepacket is amplified more than the tail part, producing negative group delay times. For the 30 cm air-gap length, shown in FIG. 7, the tunneled energy is greater than the source energy as shown in FIG. 3 and the tunneled wavepacket hugs the trailing edge of the source wavepacket. This effect identifies a causality restriction. The tunneled and source wavefronts must be simultaneous as required by the special theory of relativity. Causality requires the computed tunnel time to be $\tau = [(2L/c) - \tau_s]$ for air-gap lengths of 30 through 70 cm.

FIG. 8 shows a measurement of the daily oscillation of the centroid time (which is used to define the tunneling time which is equivalent to the change in the vector vacuum group velocity of light) with tunneling direction. This tunneling direction is in turn equivalent to the cosmic microwave background dipole direction created by the Doppler shift caused by the Earth's motion. Accordingly, the one way light velocity and Reichenbach coefficients can be measured.

The Doppler redshift direction vector points in the direction of declination 7.22° closest to the sun on March 7th with a right ascension of 23.20 h and is in the opposite direction to the Earth's motion that causes the cosmic microwave background Doppler shift.

The measured daily oscillation of the tunnel time is equivalent to the change in the vector vacuum group velocity of light with tunneling direction. When the tunneling direction is in the direction of the red shift in the cosmic microwave background the tunneling time is shortest. When tunneling is in the blue shift

direction the tunneling time is longest.

The measured daily oscillation of the tunnel time is due to a change in the vector vacuum group velocity of light c(AB), as a function of tunneling direction (AB), and the Reichenbach clock coefficients, as described in Equations (1) and (2). Utilizing the prototype system, the one-way light group velocity can be measured and compared with these theoretical values.

The vector vacuum phase velocity of light was measured at an air-gap length of 220 cm. FIG. 8 shows a histogram mean value data of the centroid time over a twenty-four hour period of measurement. The 9308 has a histogramming bin width of 1.22 ps over the 80 ns window. At L = 220 cm, the standard deviation lower bound, $\Delta\tau(\min)1 = \Delta X/2c = 507$ps, requiring millions of pulser pulses to decrease the error in the centroid time histogram mean value below a picosecond. The 9307-discriminator level was set as high as possible without effecting the count rate. The tunneling direction was parallel to the Earth's surface at 108°, fixing the tunneling direction declination at -12°. A typical data set showing peak time statistics in ns for ten spectrum centroids is summarized in Table 3, below:

Table 3: Centroid Time Oscillation Data	
Mean	47.010
Median	47.011
RMS	47.010
Standard Deviation	0.0029258
Variance	8.5604 e^{-6}
Standard Error	0.00092523
Skewness	1.0718
Kutosis	0.97325

As the measured daily oscillation of the centroid time is equivalent to the change in the vector vacuum phase velocity of light with tunneling direction, and as the tunneling direction is equivalent to the cosmic microwave background dipole direction created by the Doppler shift caused by the Earth's motion, the one way

light phase velocity is measured, and the Reichenbach clock synchronization coefficients can be determined.

Although the above embodiment was only utilized to measure the one way light phase velocity, it will be obvious to one of skill in the art that other uses for the oscillating tunneling time measurements could be made. For example, using the tunneling time oscillation to measure the group velocity of light. In addition, the vector group velocity of light can be used as a compass relative to the cosmic background Doppler redshift direction or as a clock and calendar by also knowing the Earth's motion.

Although specific embodiments are disclosed herein, it is expected that persons skilled in the art can and will design alternative light velocity vector measurement systems that are within the scope of the following claims either literally or under the Doctrine of Equivalents.